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January 20, 1998

NERC OPERATING COMMITTEE
 MAIN OPERATING COMMITTEE
 MAIN ENGINEERING COMMITTEE
 MAPP RELIABILITY COUNCIL
 MAPP OPERATING REVIEW SUBCOMMITTEE
 MAPP MAIN INTERFACE GROUP

Attached is the report of the events surrounding the June 11, 1987 trip of the Arpin-Rocky Run 345kv line located in North Central Wisconsin. The facility is located on the MAPP MAIN Wisconsin interface, and had significant effect on both MAPP and MAIN members.

This event clearly indicated the need for a cooperative Interregional review, and subsequently three groups of MAPP and MAIN members were created to study and coordinate Phase Angle, Dynamics and Relaying aspects of the event. The focus of each group was to investigate the event, and to develop processes to minimize the likelihood of recurrence.

This report addresses the event itself, but it should be noted that the cooperative effort between MAIN and MAPP did not end here. MAIN and MAPP continue to work on regional problems and differences in the realm of Line Loading Relief and ATC calculations, and are making significant progress in finding common ground that will lead to resolution of issues that concern both regions.

Very truly yours,

Shel Berg
 MAPP Region

Dave Hill
 MAIN Region

c: Jim Brown, DOE
 Greg Cucchi, NERC OC Chair
 Don Benjamin, NERC
 Marty Mennes, NERC SCS Chair
 Paul McCoy, CE

Summary of Minnesota - Wisconsin Separation June 11, 1997

INTRODUCTION

The electric transmission system in the upper Midwest consists of primarily a 345 kV transmission system with underlying 161 and 138 kV lines. Large amounts of economical generating capability exist within the MAPP region both in the coal fields in Western MAPP and in Manitoba Hydro. This often results in economic incentives in an open marketplace to move large amounts of this economical energy to higher cost areas to the east and south. Historically, the flow on the MAPP - Wisconsin interface was limited by voltage constraints within MAPP. However, partly due to the capacity situation in MAIN for the summer of 1997 and the desire to increase capabilities, many capacitors were added to the 345 kV circuit from MAPP to eastern Wisconsin to alleviate the voltage limitation.

JUNE 11, 1997 INCIDENT

On June 10, 1997, large amounts (historical levels) of power were being exported from MAPP to the MAIN region to the east (1349 MW to MAIN with MAIN to TVA and ECAR exports of 1955 MW and MAIN to SPP of 175 MW) and simultaneously from MAPP to the SPP region to the south (2107 MW). In addition, there were north to south transfers within MAPP. These record energy schedules resulted in high flows on a number of 345 kV transmission lines within the MAPP and MAIN regions.

Some transmission lines in the Nebraska area were approaching guide limits. As a result, the MAPP Center was in the early stages of Line Loading Relief, and had already collected schedule information for H.E. 0100 in preparation for schedule reductions to alleviate transmission loading on the MAPP-SPP interface.

Shortly after midnight on the night of June 10 and morning of June 11, the Arpin to Rocky Run 345 kV line between MAPP and MAIN in central Wisconsin tripped. The relays at the Rocky Run substation tripped at an ampere level below their settings, possibly due to unbalanced phase currents. The trip of the Rocky Run breakers reduced the flow on the interface enough to trip two Eau Claire capacitor banks due to high voltage. The subsequent automatic reclose of the Rocky Run breakers returned the high flow, but without the assistance of the two Eau Claire capacitors. Without the capacitor banks, the voltage dropped and current increased to a point that tripped breakers at Arpin. This resulted in the opening of the Minnesota - Wisconsin, MAIN - MAPP interface.

This line loss resulted in increased energy flow to the south through MAPP. It also produced low voltages in southeastern Minnesota, southwestern Wisconsin, eastern Iowa and northwestern Illinois, heavy loading of parallel systems and a large phase angle across the open tie (95-1200) at the Arpin Bus. This required a re-dispatch of generation, ramping up in MAIN and down in MAPP, in order to reduce the phase angle to allow the line to be closed.

The MAPP Center was able to begin reducing schedules very quickly to start lowering line flows and exports. Meanwhile, MAIN companies began ramping generation up in a coordinated effort to reduce the Arpin phase angle to a low enough value to reclose the 345 kV line.

At the time that the Arpin breaker opened, loading increased on the already heavily loaded Cooper to St. Joseph and the Cooper to Fairport 345 kV lines between Nebraska and Missouri due to the export schedules from MAPP to SPP and to MAIN. These loading conditions were near relay limits and triggered overloading alarms at Nebraska Public Power District's (NPPD) Cooper Station. A subsequent load flow analysis of the situation by NPPD investigating a potential subsequent trip of the Cooper to St. Joseph 345 kV line revealed that, had this line tripped, every remaining 345 and 161 kV tie into SPP and MAIN would have been overloaded. This would likely have resulted in a separation of the MAPP system.

The prompt actions of system operators in MAIN and MAPP to raise generation in Wisconsin and to reduce generation in northern MAPP certainly helped to prevent further uncontrolled relaying. Approximately two hours after the initial trip of the Rocky Run breaker, the phase angle across the open breaker at Arpin had been reduced to 57° and the line was reclosed by the operators returning the system to normal.

ACTIONS SUBSEQUENT TO INCIDENT

Following the incident, relay engineering personnel reviewed the incident. The relays were tested in the field and a system bench test was conducted to attempt to replicate the event. No problems were found and the event could not be replicated on the bench. The trip setting of the relays were raised on June 13th at both Arpin and Rocky Run and the Rocky Run to Arpin automatic reclosing was disabled on June 25th 1997.

Three groups were commissioned to investigate this event and make recommendations in three areas. A Phase Angle Committee was formed and the MAIN Dynamics Task Force and Relay Task Force were expanded. These groups are made up of MAIN and MAPP representatives.

Minnesota - Wisconsin Phase Angle Committee

A Minnesota-Wisconsin Phase Angle Committee was established by MAIN including MAPP members to determine actions necessary to limit the phase angle should the 345 kV line from MAPP into Wisconsin trip.

The Minnesota-Wisconsin Phase Angle Committee published a 15 page final report concerning the June 11 trip on June 18, 1997. This committee also published a 2 page report with pre-contingency line loading limitations on June 20 with a 8 page revision on July 18, 1997, and August 15, 1997 including a method to reduce the phase angle after opening of the Minnesota-Wisconsin interface.

The following limits were established as measured at Arpin on the line from Eau Claire. These limits are based on low voltages and open circuit phase angle after loss of Eau Claire - Arpin during high loading.

At a loading level of 775 MW:

WPL system operations will inform MAIN to institute Main Guide 1C to collect and hold schedules impacting Eau Claire to Arpin. MAIN, through Guide 1C notifies MAPP to collect and hold schedules. MAPP will declare MAPP condition "Yellow".

WPL system operations will notify MAIN to institute Main Guide 1C, for the purpose of holding schedules impacting flows from the Eau Claire - Arpin line. WPL will also inform the MAPP center of this action. MAIN will coordinate schedule holds with the MAPP center.

At a loading level of 825 MW:

WPL will inform MAIN to cut schedules to reduce flow on Eau Claire - Arpin to a level of less than 800 MW.

Since June 11, 1997, flows on the Eau Claire - Arpin 345 kV line have required using the Arpin loading guide frequently. Experience has shown that these loading limits are appropriate. However, there still needs to be a proactive method of limiting the flows on the Eau Claire - Arpin 345 kV line. Such a method must recognize the real world limits in the calculation and application of ATC. Schedules should be limited through the scheduling process rather than waiting for line loading relief. This is further evidenced from the following problems which have occurred occasionally with these limits.

Low voltage at Arpin. This voltage was improved after installation of capacitor banks at Arpin on June 30, 1997.

Automatic tripping of the 69 kV DFC - WPL ties at Council Creek and Hilltop Flows ramp up quickly with 30 MW increases at any time and with larger increases or decreases during schedule changes at 0000, 0600, and 2200.

The Minnesota-Wisconsin Phase Angle Committee has developed and approved a coordinated method of ramping up generation in MAIN and ramping down generation in MAPP after tripping of the Minnesota-Wisconsin 345 kV line. This procedure is needed before the line can be reclosed due to the large phase angle between western and eastern Wisconsin. This phase angle increases after of the Minnesota-Wisconsin 345 kV line trips, because lower voltage transmission systems between MAPP and MAIN overload and consequently automatically trip.

Closing this line while the phase angle between the systems is larger than 60 degrees, has caused problems with generators near the closing point. The most affected unit is Weston 3, a base load coal unit near Wausau, Wisconsin.

Dynamics Task Force

In addition, the MAIN Dynamics Task force was expanded to include MAPP personnel and is performing dynamic studies to review the limits from a dynamic stability perspective. The Task Force has collected actual data from the incident and is working to build a dynamics model. The NERC SDDWG (System Dynamics Database Working Group) model is being utilized to perform the analysis. The dynamics model required to fully analyze the MAPP-MAIN interface is much larger than existing models used by MAIN and MAPP members for analysis within their own areas. The task force has invested a considerable amount of work in the building and tuning of this large model. The Task Force will then validate the SDDWG model by simulating the actual events of June 11. From this validated model, other contingencies will be examined and the system stability tested. Special interest will be paid to the operation of the large amounts of capacitor banks applied to this particular 345 kV circuit. The task force will recommend an operating strategy for the capacitor banks. This work is expected to be completed in the next few months.

Relay Task Force

The MAIN Relay Task Force was also expanded to include appropriate personnel from MAPP and Minnesota companies. The group reviewed the report and actions of the Wisconsin group. Their recommendations were found to be appropriate. The relays at Arpin and Rocky Run are scheduled to be replaced in 1998. In addition, the Relay Task Force is expected to work closely with the Dynamics Task Force to implement any system protection recommendations that may result from the dynamic analysis.

FURTHER ACTION

Coordination of ATC Values

It is essential that posted ATC values be coordinated between regions and reflect limitations in other systems as calculated by all parties as required by NERC policy. The importance of accurate ATC values is reflected in the need to preserve a viable transmission marketplace

Proactively Adhering to the ATC limits

If the phase angle across an open Arpin - Eau Claire circuit is to be limited by limiting the flow across the interface, then the posted ATC values must be based on this limit and adhered to when selling transmission. This is the case both for control area to control area transactions as are the norm in MAIN and for regional tariffs as is the case in MAPP. Further, all transactions, both firm and non-firm, hourly and longer, grid wide arrangements, and point to point service must all be included in the decrementing of the ATC values.

Coordination of Transmission System Loading Relief Procedures

When the actions of the parties to proactively limit the flow on the transmission system fail and the system meets or exceeds the limits, implementing relief procedures serves as the final step. These procedures must be coordinated when the problem is created by transactions that produce effects on others systems. This coordination should include:

- Clear rules across regions for holding of energy schedules.
- Clear understanding of the priority levels of the schedules.
- Joint processes for curtailing schedules.
- Joint processes for releasing curtailments and reloading schedules.
- Joint processes for returning to normal operation.

Steps taken to implement these further actions necessary

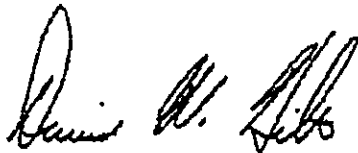
On September 29th, 1997, a meeting was held between the parties in Chicago. The parties agreed to form a task force to be co-chaired by the security coordinators in each region. This task force is to undertake each of these issues with the exception of the relief procedures. The transmission loading relief procedures will be undertaken by the security coordinators themselves and will also include the Southwest Power Pool. While a final date for resolving all of these issues is uncertain, the parties involved recognize that this is a high priority issue and they will address it in the most timely manner possible. It is expected that most of these issues can be addressed by January 1, 1998.

CONCLUSIONS

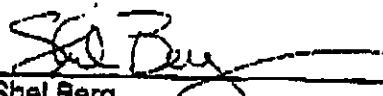
The study work of NPPD indicated that the MAPP system, on the night of June 10 - 11th, 1997, came within a few megawatts of a system separation. Their work speculated on what might have happened with such a separation including under frequency and over frequency tripping of loads and overspeed tripping of generating units. It was suggested that some regional blackouts could have occurred. Such blackouts would likely have been on a smaller scale than those that occurred in the Western United States, but no less significant to those affected.

The importance of this near miss cannot be ignored. The need to effectively manage the interfaces on a proactive basis is evident. In order to manage these interfaces, all parties including regional centers, providers and the marketplace must work together to preserve the reliability of the interconnected network and to provide for a viable transmission marketplace.

Much work has taken place since the incident on June 11, 1997. This work has been initially to prevent the repeat of the conditions that existed that night. However, line loading relief continues on a frequent basis and the risk of rapid changes in the flow on the facility remain as energy schedules are added. Much work remains to be accomplished in order to fully coordinate the use of this critical interface. It is hoped that much of this work will be accomplished by January 1, 1998. Both MAPP and MAIN and their respective members are committed to resolving these issues in an expeditious manner to both maintain the reliability of the transmission system and to preserve a viable transmission system marketplace.



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